(12) UK Patent Application (19) GB (11) 2 167 055 A

(43) Application published 21 May 1986

(21) Application No 8428656

(22) Date of filing 13 Nov 1984

(71) Applicant
Biosystem E AB (Sweden),
Sandgardsgatan 14-16, S-352 30 Vaxjo, Sweden

(72) Inventors
Karl Jonas Norrman,
Antonin Pola

(74) Agent and/or Address for Service
Mewburn Ellis & Co., 2/3 Cursitor Street,
London EC4A 1BQ

(51) INT CL[4]
C02F 3/30

(52) Domestic classification
C1C 311 331 431 432 436 43Y 442 621 622 632 635 702 70Y K

(56) Documents cited
GB A 2013170 US 4315823

(58) Field of search
C1C

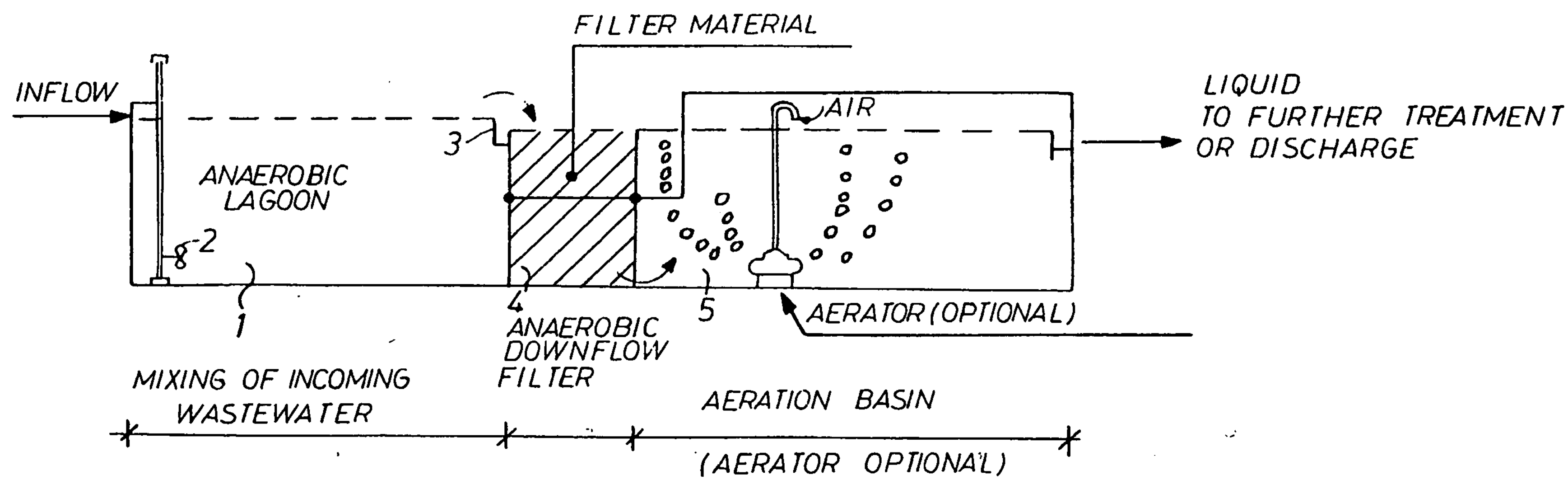
(54) Method and apparatus for the treatment of wastewater and organic waste material

(57) The process takes place in three steps, viz. 1) anaerobic degradation in a lagoon of high molecular complex organic material in the wastewater stepwise to low molecular soluble organic compounds, further to acetate, H_2, CO_2 and finally to biogas (methane + carbon dioxide) by a consortium of microorganisms including methanogens, 2) further conversion of low molecular compounds to biogas in an upflow or downflow anaerobic filter containing dense populations of microorganisms, mainly methanogens, and 3) final aerobic biological treatment (polishing) of the wastewater in an aerobic treatment unit.

The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.
This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1982.

2167055

1/1



FILTER MATERIAL
INFLOW
LIQUID
TO FURTHER TREATMENT
OR DISCHARGE
AIR
3
ANAEROBIC
LAGOON
2
8
1
4
5
AERATOR (OPTIONAL)
ANAEROBIC
DOWNFLOW
FILTER
MIXING OF INCOMING
WASTEWATER
AERATION BASIN
(AERATOR OPTIONAL)

SPECIFICATION

Method and apparatus for the treatment of wastewater and organic waste material

The present invention relates to a method and an apparatus for the treatment of wastewater and/or organic waste material.

A considerable number of treatment systems for purification of wastewaters of different kinds have been developed in recent years. Most of these are relatively complicated treatment plants requiring sophisticated and expensive equipment for regulation and control to function satisfactorily. At large wastewater treatment plants, e.g. municipal sewage treatment works or large industries, the investment costs are not of decisive importance, because the costs can be spread over huge amounts of treated wastewater. On the other hand, at small treatment plants, e.g. treatment plants for pig waste, the investment costs are of major importance for the economic viability of the plant. Consequently, there is an obvious need for wastewater treatment plants that are efficient, reliable and cheap to build and operate.

One treatment system for wastewater earlier described consists of an anaerobic lagoon and subsequent treatment in an anaerobic filter filled with stones (see e.g. "Anaerobic Treatment of Pulp and Paper Wastes", Pulp Pat. Can., 1982, 83, *9* 70-73). The direction of flow through the stone filter is horizontal. The stone filter has certain drawbacks, the major one being the low porosity of the filter media (stones). The void volume of the stone filter available for wastewater flow is only approx. 45% of the total filter volume. Furthermore, stones are heavy and the surface area is small. Consequently, a stone filter must be large in relation to the amount of wastewater treated and requires a considerable space. Furthermore, the construction must be solid because of the density of the stone, resulting in an expensive treatment system of doubtful cost efficiency for small-scale treatment plants.

The object of the present invention is to achieve a procedure and an apparatus for efficient, reliable and cheap treatment of wastewaters, e.g. pig waste or industrial wastewaters. The treatment procedure and apparatus are especially suitable for use in a warm climate, but can be modified for use in a tempered climate, too.

The treatment procedure according to the invention consists of the following three steps:

A. Anaerobic biological degradation in a lagoon of high molecular complex organic material (pollutants) in the wastewater to low molecular soluble intermediates by hydrolysing and acid-producing microorganisms, further conversion to acetate, H_2 and CO_2, and partly further to biogas (methane + carbon dioxide).

B. more complete conversion of the low molecular soluble compounds to biogas in an upflow or downflow anaerobic filter (=anaerobic fixed bed reactor) containing a dense population of microorganisms, mainly methane-producing bacteria, and

C. one or more final aerobic biological treatments (polishing) of the wastewater (=effluent from the anaerobic filter).

Step C may consist of treatment in one or more activated sludge units, trickling filters, aerated lagoons or oxidation ditches or other kind of aerobic treatment step, and the treatment is preferably divided into an aeration stage and a clarification stage.

The invention also includes an apparatus for treating wastewater which consists of:

a. an anaerobic lagoon for hydrolysis and liquefaction of complex organic material in the wastewater to low molecular, soluble organic compounds, further conversion to acetate, H_2 and CO_2, and partly further to biogas (methane + carbon dioxide),

b. an anaerobic filter, either upflow or downflow, for further degradation of low molecular soluble, organic compounds to biogas by methane-producing bacteria, and

c. one or more aerobic treatment steps for final biological degradation of the wastewater.

The filter media in the anaerobic filter will support the attached active microorganisms, mainly methanogens, and should have the following properties:

- low density
- large void volume = high porosity
- large surface area
- surface properties suitable for attachment of microorganisms, e.g. suitable pore size
- low cost

One possible material consists of corrugated plastic sheets with a large surface area per m^3 of material. The porosity of this material is approx. 95%, compared to approx. 45% for the stone filter medium mentioned above. Plastic media of this kind have a considerably smaller total volume than a stone filter with the same treatment capacity, i.e. the efficiency is higher than for a stone filter. Because of the small volume it is also easier to cover the filter with a gas-tight cover or gas holder if collection of the biogas produced is required. Furthermore, plastic media have a low density compared to stone and, therefore, the support structures of the filter can be constructed of wood or light concrete, decreasing investment costs.

Another advantage by using plastic media with a high porisity is the low risk of clogging of the filter. The flow resistance is low and, consequently, the wastewater can flow through the whole treatment system, using minimal pumping.

Alternative carrier materials are possible as filter media as long as they fulfil the criteria of low density, high porosity, large surface area, suitable surface properties for attachment of microorgnanisms and low cost. Possible as filter media are plastic media other than corrugated sheets, activated carbon, ceramic materials, sea shells, coconut fibres, pieces of wood and similar materials.

Figure 1 illustrates an embodiment of an apparatus according to the invention.

The wastewater to be treated is discharged into an anaerobic lagoon 1 provided with a mixing device 2. In this anaerobic lagoon, degradation of complex organic material in the wastewater takes place. The organic pollutants are degraded stepwise to low

molecular soluble organic compounds, mainly volatile fatty acids, and further to acetate, carbon dioxide and hydrogen. These intermediates are finally converted to biogas, methane and carbon dioxide.

The wastewater leaves the lagoon over a weir 3 and flows, e.g. by gravity, into an anaerobic filter 4 which is filled with filter media, e.g. the plastic material "PLASdek" (corrugated plastic sheets with a large area provided by Munters). The wastewater is flowing freely in a downward direction and is further purified by contact with active microorganisms attached to the filter medium. Part of the microorganisms may appear as free flocks in the interstices of the filter, which is especially important if the filter is operated in an upflow direction. The high concentrations of microorganisms present in a filter efficiently convert soluble organic pollutants to biogas. After filter treatment, the wastewater is led into the aeration basin 5 where it is oxygenated by using, e.g. submerged aerators or other kinds of aerators. By aerobic treatment, remaining pollutants in the wastewater are biologically degraded in one or several treatment steps until current effluent standards are met.

In Figure 1, the anaerobic filter is depicted with downflow operation, but upflow is equally efficient. Flow in a horizontal direction should not be employed.

If dilute pig waste is treated according to the procedure shown in Figure 1, a BOD_5-reduction from 6,000 mg/litre to 50 mg/litre can be achieved. The hydraulic and solids retention times in the different treatment steps must of course be adjusted according to current effluent standards. It may be necessary for instance to use two aerobic treatment steps in series to meet particularly stringent effluent standards.

The treatment procedure and the apparatus according to the invention are suitable for continuous stable operation, and operation costs are very low because of the few moving parts. Furthermore, the wastewater is flowing through the anaerobic filter by gravity and, therefore, no expensive pumps are necessary, at least in this step.

By adjusting the hydraulic retention times of the different treatment steps, the treatment system can be designed to operate at a psycrophilic temperature (7-20°C), a mesophilic temperature (20-44°C) or a thermophilic temperature (45-70°C).

If the aerobic stage is divided into an aeration basin and a settling basin, part of the settled sludge from the settling basin can be recirculated to the anaerobic lagoon and the rest, i.e. the excess sludge, disposed of after dewatering.

Usually, the biogas produced by the methane fermentation (anaerobic digestion) is not collected but, if this is required, the anaerobic filter and possibly also the anaerobic lagoon can be covered by a gas-tight cover of e.g. Hypalon, or a floating gas holder. Biogas can be used for heating, generation of electricity or as fuel for vehicles.

CLAIMS

1. A method for the biological treatment of wastewater or organic waste material, characterised in that it includes the following steps:

A. anaerobic biological degradation of high molecular, complex compounds (pollutants) in the wastewater to low molecular soluble organic intermediates by hydrolysing and acid-producing microorganisms, further conversion to acetate, H_2 and CO_2, and partly further to biogas,

B. more complete conversion of the low molecular, soluble compounds to acetate, H_2 and CO_2, and finally to biogas in an upflow or downflow anaerobic filter containing a dense population of microorganisms, mainly methane-producing bacteria, and

C. one or more final aerobic biological treatments of the wastewater.

2. Method as claimed in claim 1, characterised in that stage C consists of biological treatment in one or more activated sludge units, trickling filters, aerated lagoons or oxidation ditches.

3. An apparatus for the treatment of wastewater or organic waste material, characterised in that it includes:

a. an anaerobic lagoon (1) for microbial hydrolysis and acidification of high molecular, complex organic compounds in the wastewater to low molecular soluble organic compounds, further conversion to acetate, H_2 and CO_2, and partly further to biogas,

b. an anaerobic filter (4), arranged for upflow or downflow, for further degradation of low molecular soluble organic compounds to biogas by methane-producing bacteria, and

c. one or more aerobic treatment stages (5) for final biological degradation of the wastewater.

4. Apparatus as claimed in claim 3, characterised in that the anaerobic filter (4) contains a filter media-material with a low density, high porosity, large surface area and surface properties suitable for attachment of microorganisms.

5. Apparatus as claimed in claim 3 or 4, characterised in that the methane-producing bacteria are at least partly immobilized onto the filter media in the anaerobic filter (4).

6. Apparatus as claimed in one or more of claims 3-5, characterised in that the anaerobic filter (4) and also the anaerobic lagoon (1) are covered by a gas-tight cover or, alternatively, comprise floating gas holder.

7. Apparatus as claimed in one or more of claims 3-6, characterised in that the anaerobic lagoon (1) and the anaerobic filter (4) are designed to operate at a psycrophilic (7-20°), mesophilic (20-44°C) or thermophilic (45-70°C) temperature.

8. Apparatus as claimed in one or more of claims 3-6, characterised in that the aerobic treatment stages (5) consist of activated sludge units, trickling filters, aerated lagoons or oxidation ditches.

9. Apparatus as claimed in one or more of claims 3-6, characterised in that the aerobic treatment stage (5) is divided into an aeration basin and a settling basin.

Printed in the UK for HMSO, D8818935, 3/86, 7102.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.